

# Smart Space - An Indoor Positioning Framework

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Research Group on Interactive Communication Systems (ICS)

# Agenda

- 1. Location Matters!**
- 2. Indoor Localisation Techniques**
- 3. SmartSpace Framework (SSF)**
- 4. Opportunities**

# Location Matters!

“Location changes everything. This one input – our coordinates – has the potential to change all the outputs. Where we shop, who we talk to, what we read, what we search for, where we go – they all change once we merge location and the Web.”

Mathew Honan, WIRED magazine, 19.1.2009

# BUT...

- Location for outdoor environments is provided by the Global Positioning System (GPS)

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<http://www.waagner-biro.at/>

... there is no solution  
for indoors yet!

# AND...

## **New generation of mobile devices with multiple sensors**

- WLAN, GSM/CDMA, IMUs and Camera
- 880 million global smartphone users by 2013 (Morgan Stanley)

## **Omnipresent RF-infrastructure in urban areas**

- WLAN: 319 million chipsets sold in 2008, with 862 million installed base (Morgan Stanley)
- GSM/CDMA

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Indoor Localisation



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## 2. Indoor Localisation Techniques

3. SmartSpace Framework (SSF)

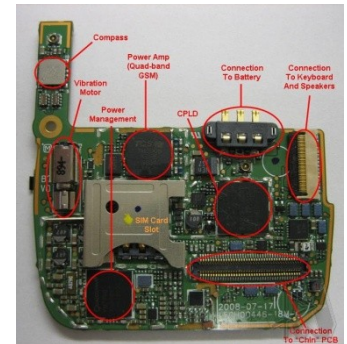
4. Opportunities

# Indoor Localisation Techniques

- **Location Fingerprinting (LFPT)**
  - Signal Strength Measurements
    - WLAN RSSI
    - GSM RSS
- **Inertial Measuring Units (IMUs)**
  - Accelerometer
  - Gyroscope
  - Electric compass
- **Marker based localisation**
  - QR-Codes
  - Display



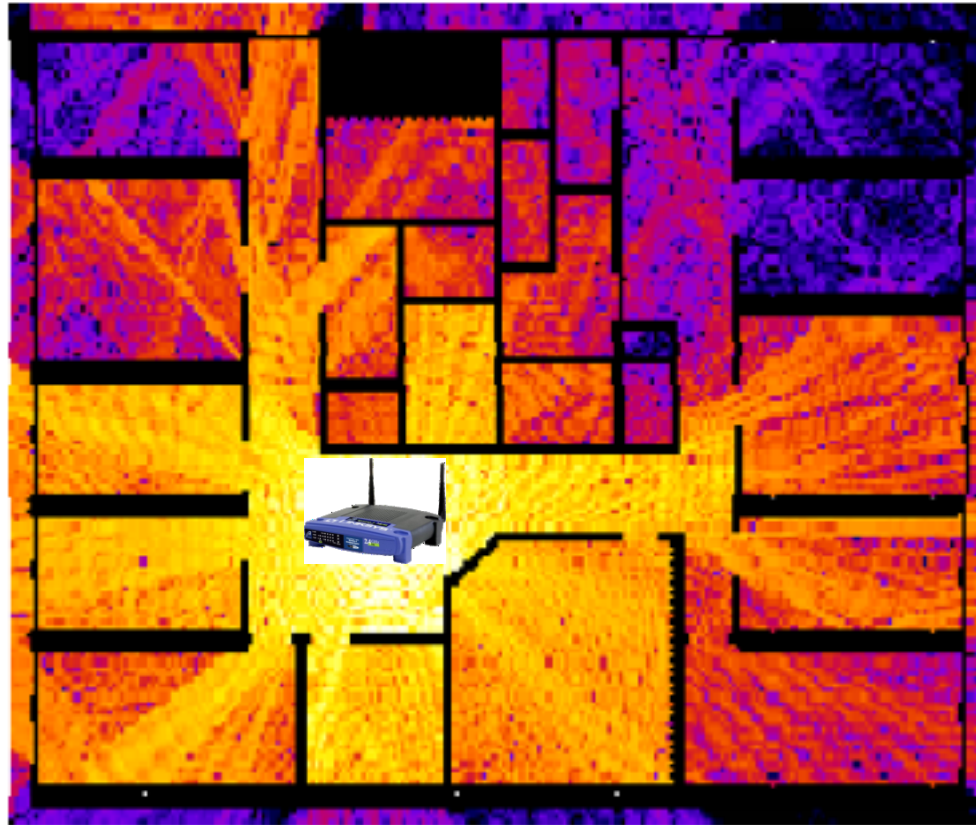
<http://www.wikipedia.de/>



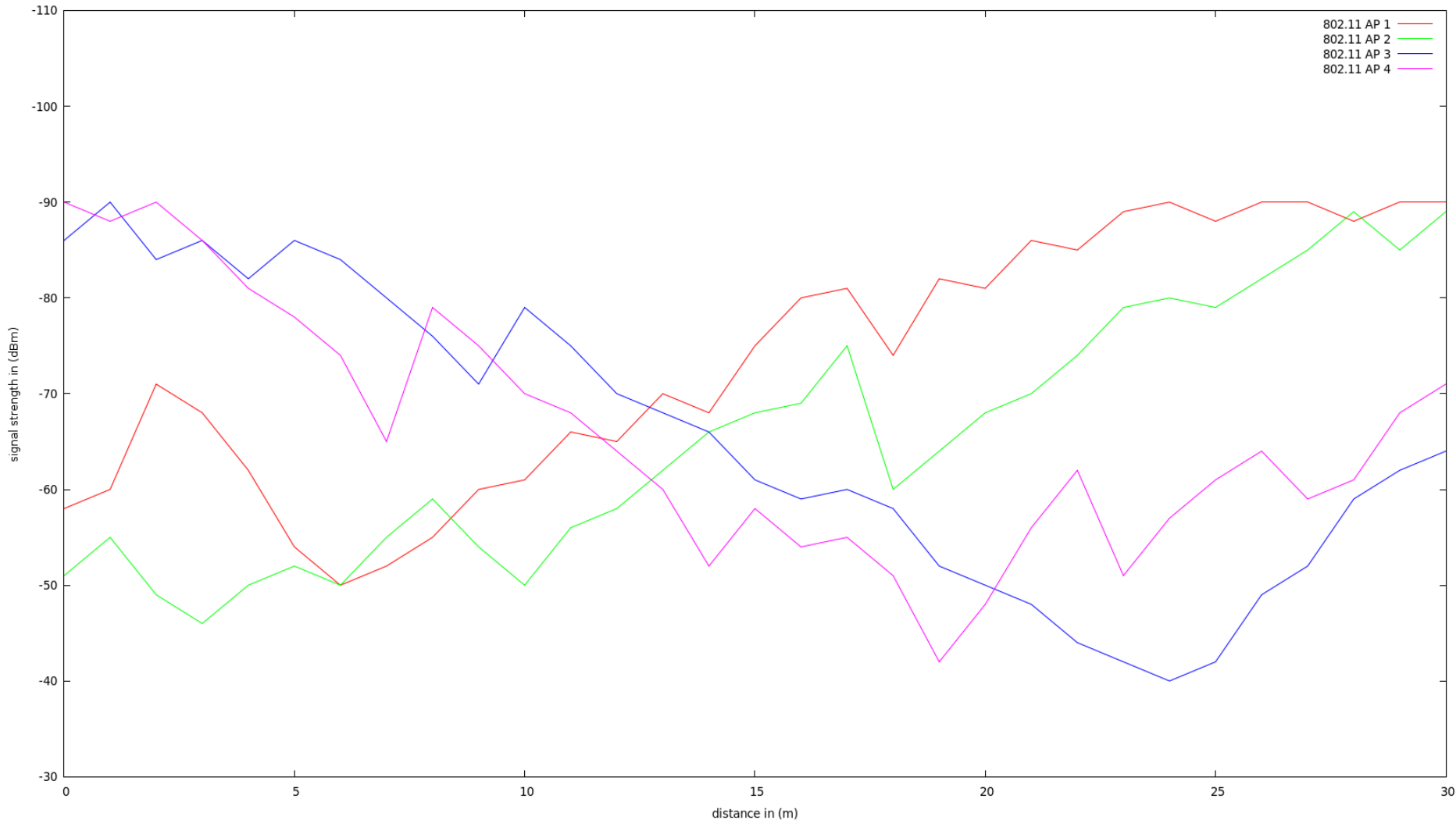
<http://www.phonewreck.com/>



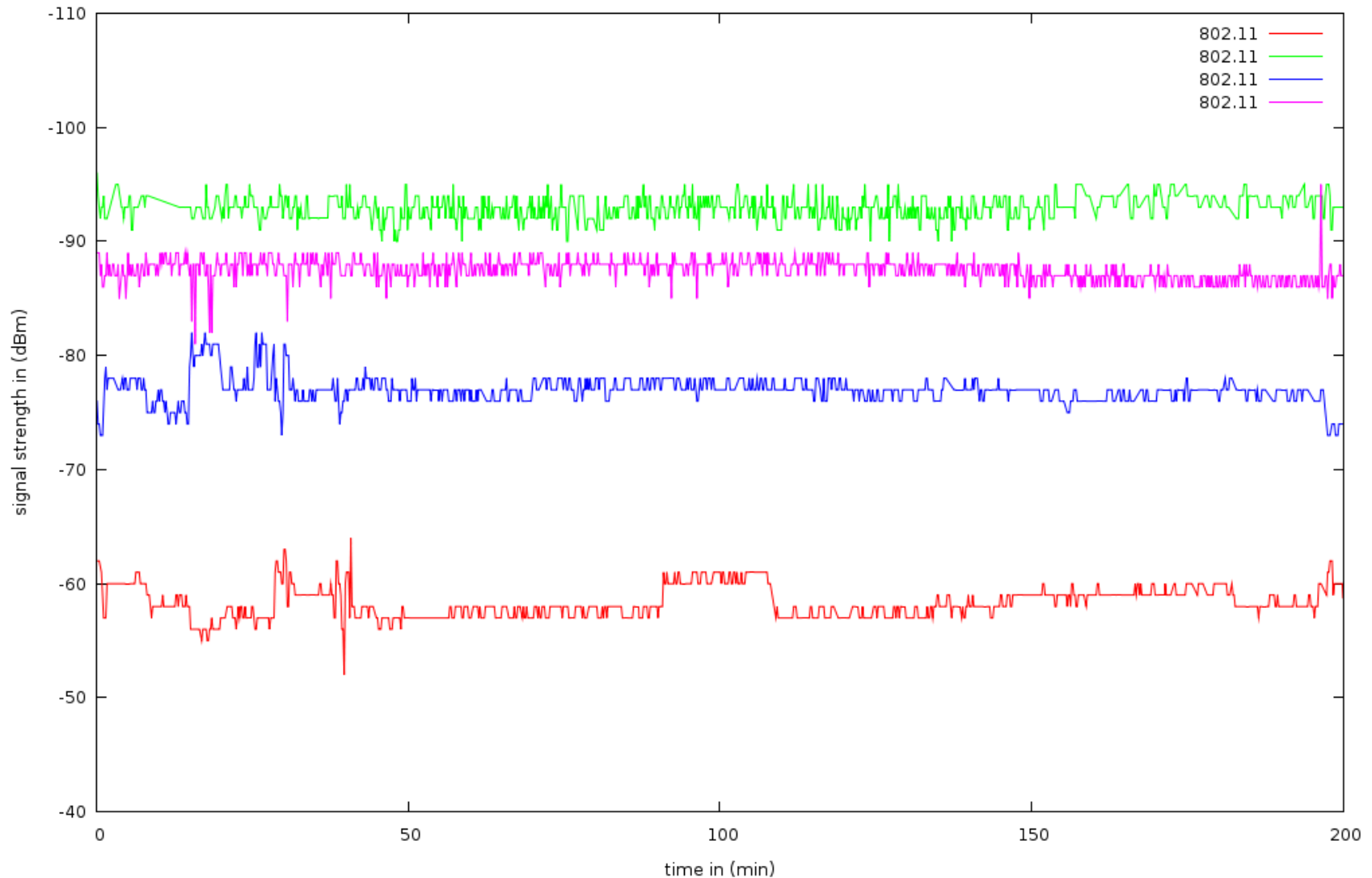
# LFPT – WLAN Radio Propagation



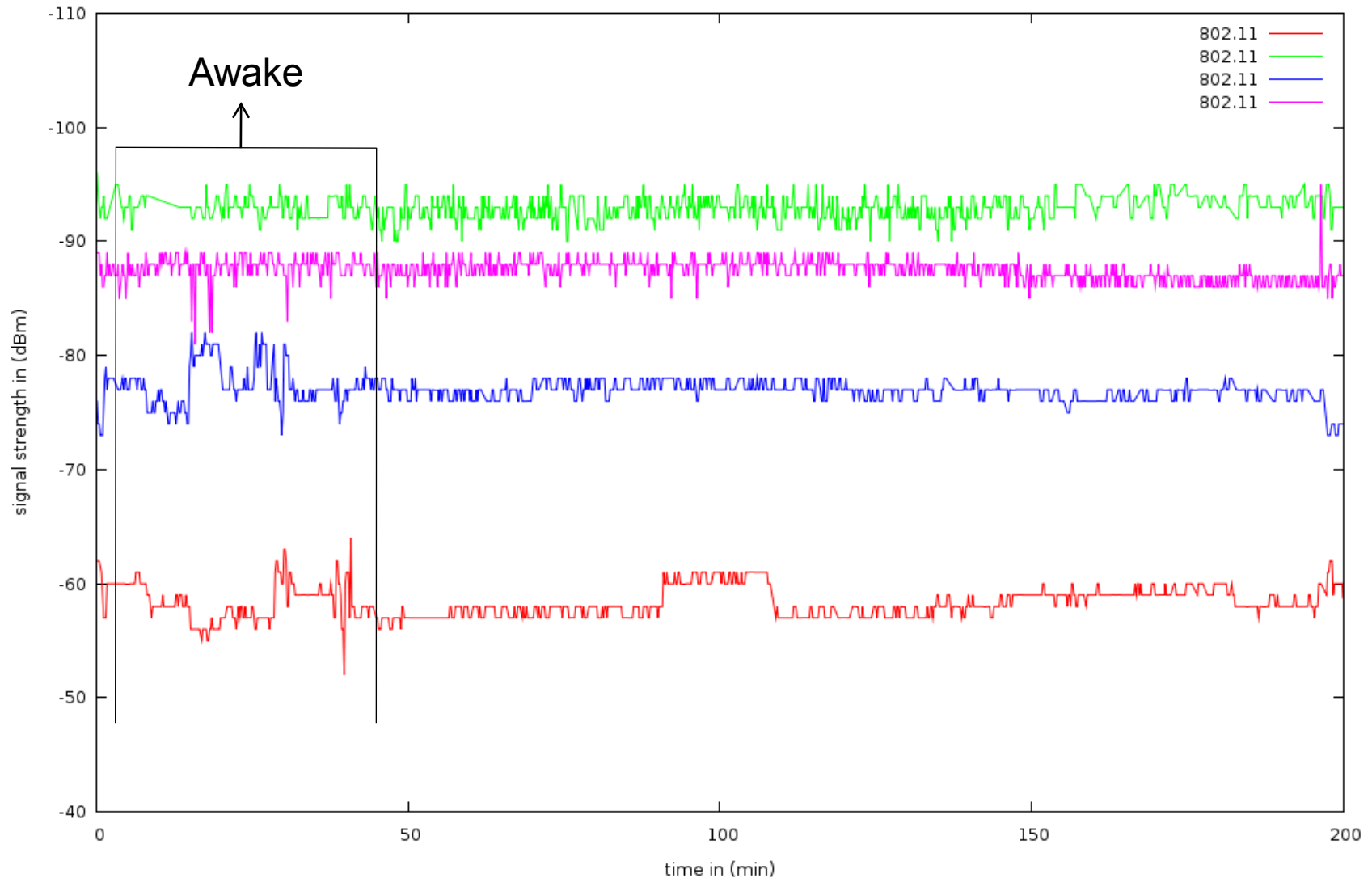
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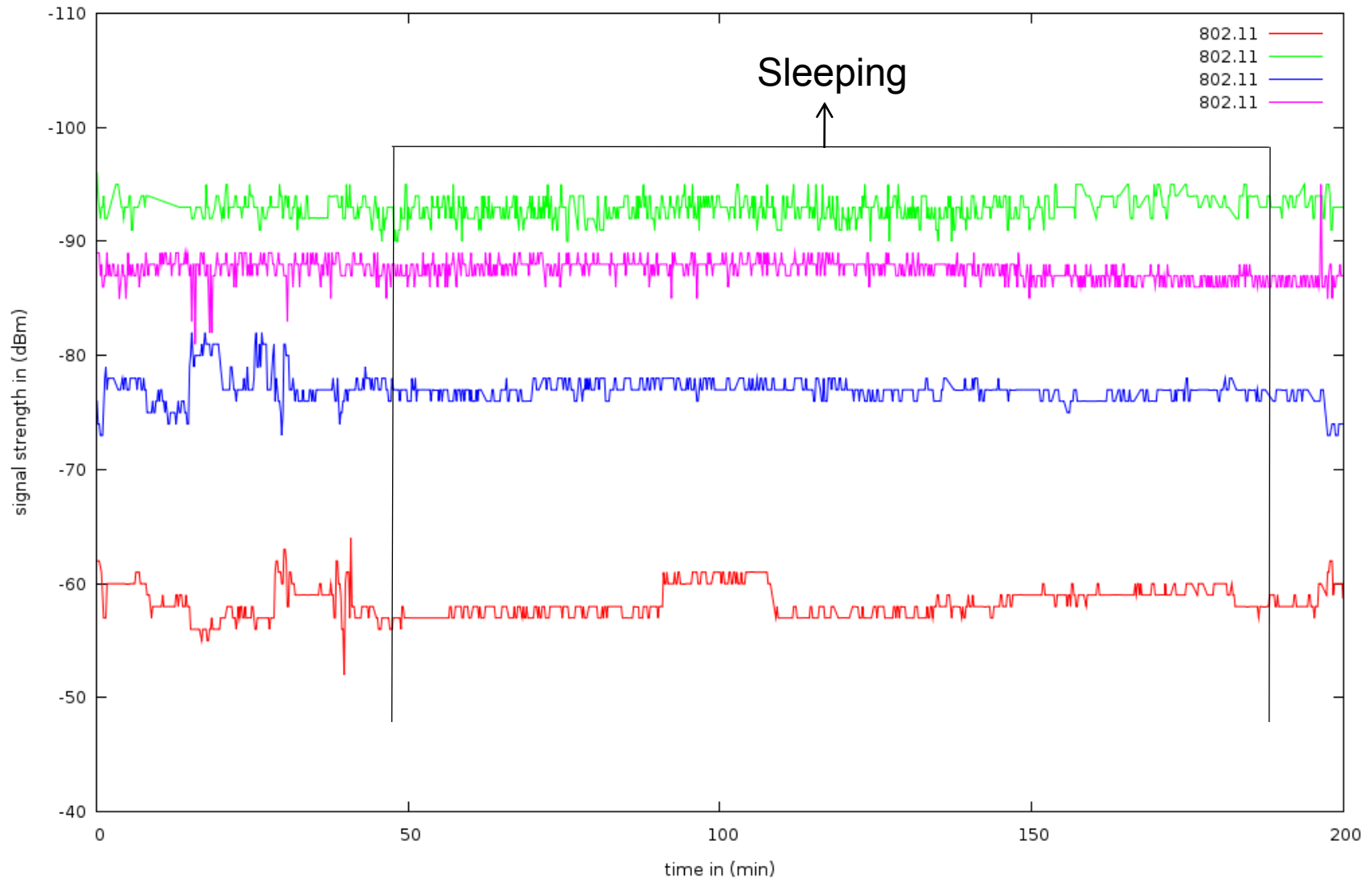
# LFPT - WLAN signal stability over time



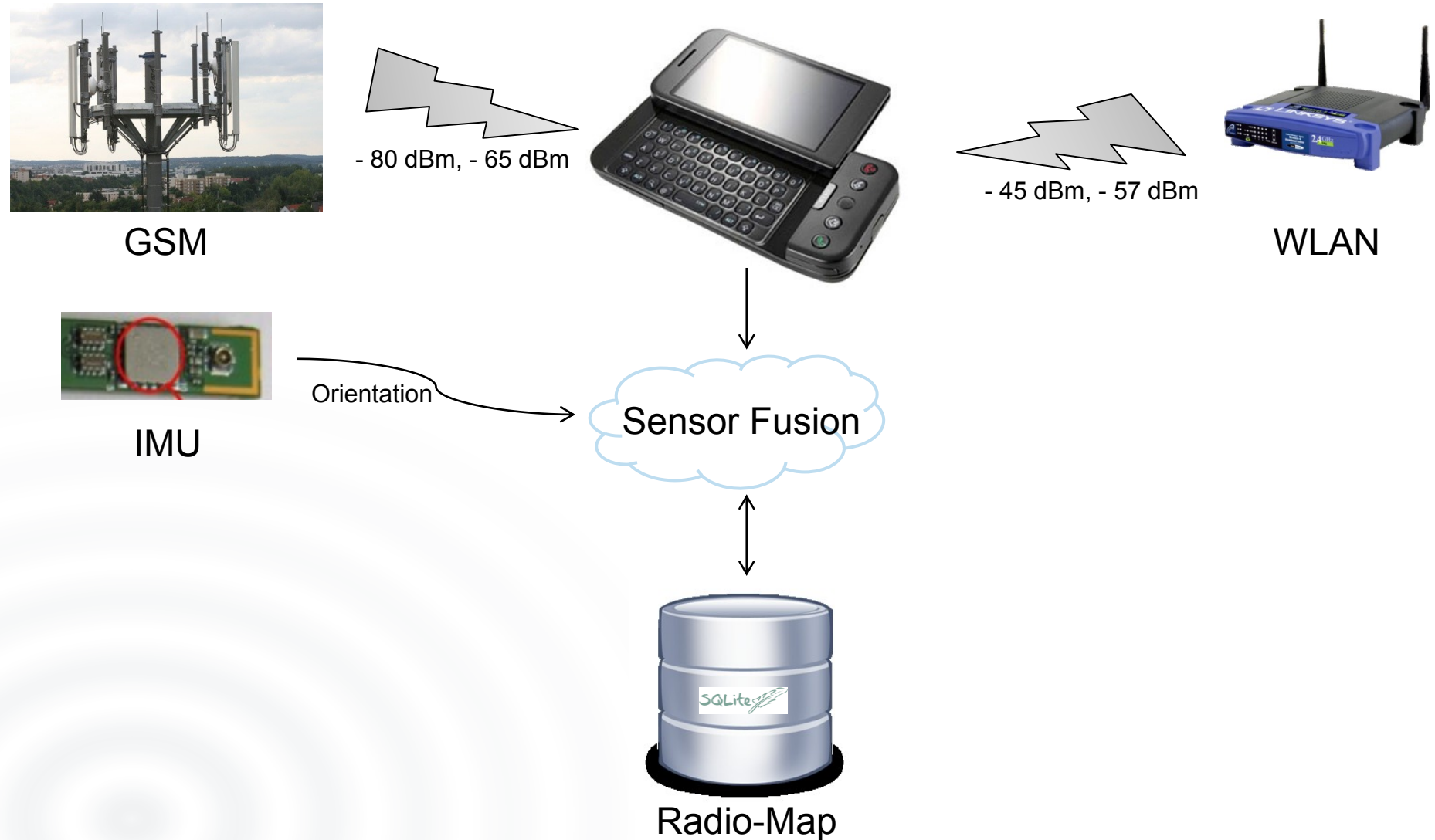
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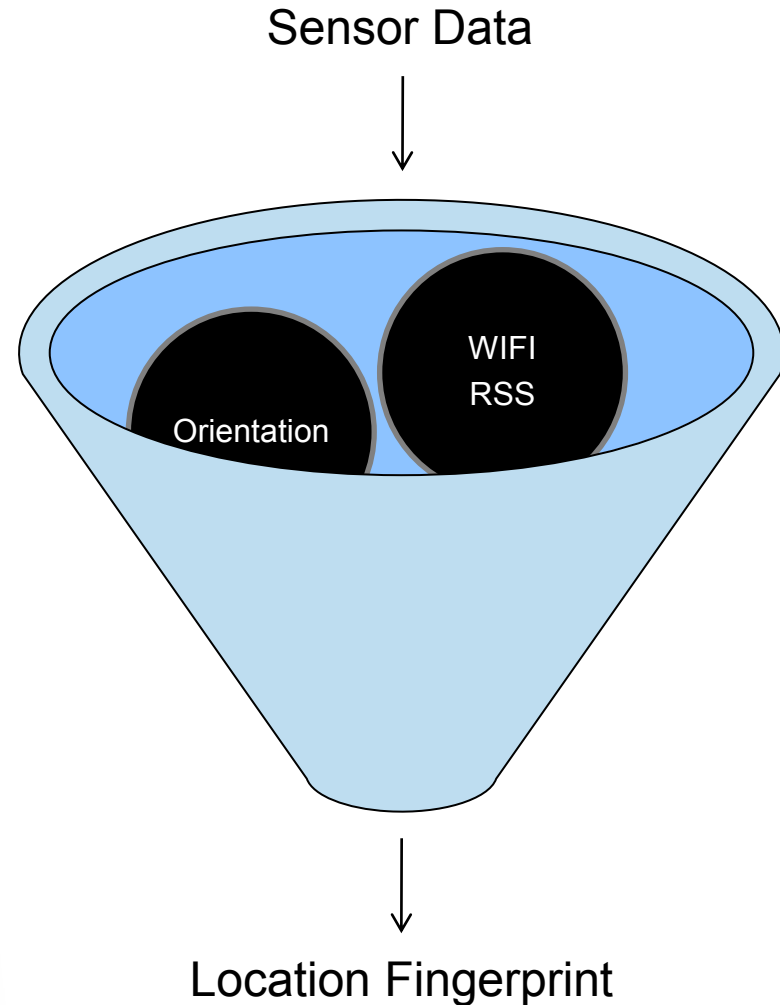
# LFPT = collect environmental sensor data





# LFPT – Sensor Fusion

- **Synchronize sensors**
  - Measurement count
  - Time
- **Normalize data**
  - Variance
  - Deviance
  - Algorithms
- **Fusionate data**
  - Kalman filters
  - Particle filters



# LFPT – How-to

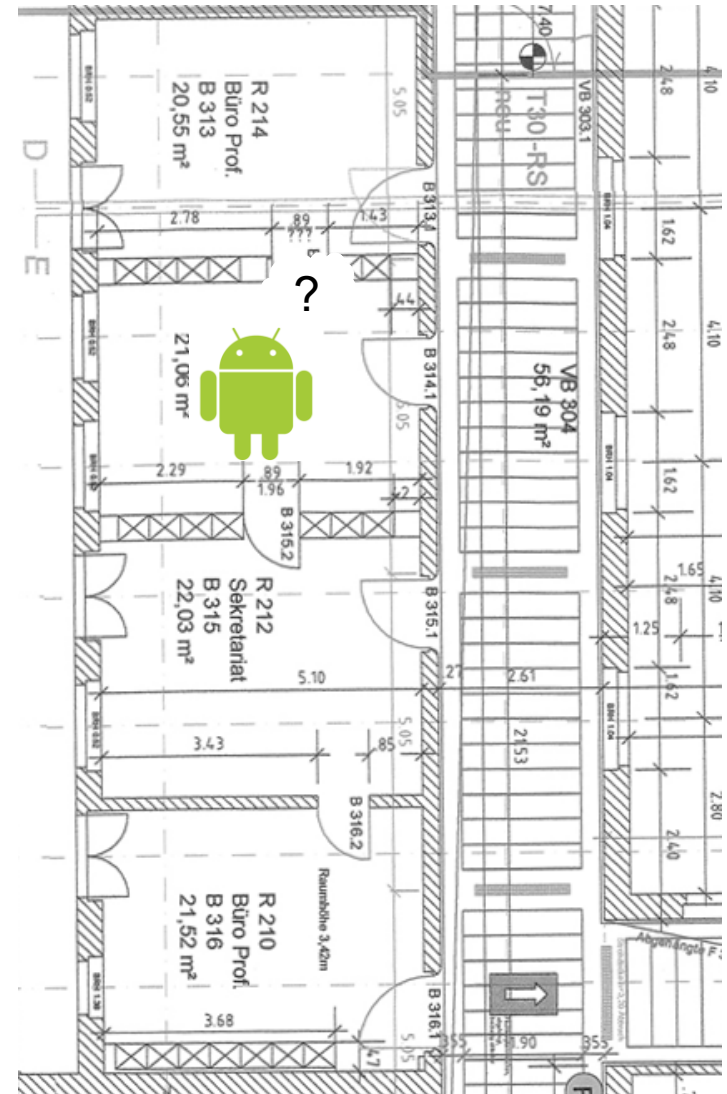
Testbed at University of Tübingen with 4 rooms + corridor:

## 1. Trainings-Phase

- Grid of Training-Points
- Record LFPTs
- Write to Radio-Map

## 2. Realtime-Phase

- Record LFPT
- Alignment with Radio-Map
- Estimate position



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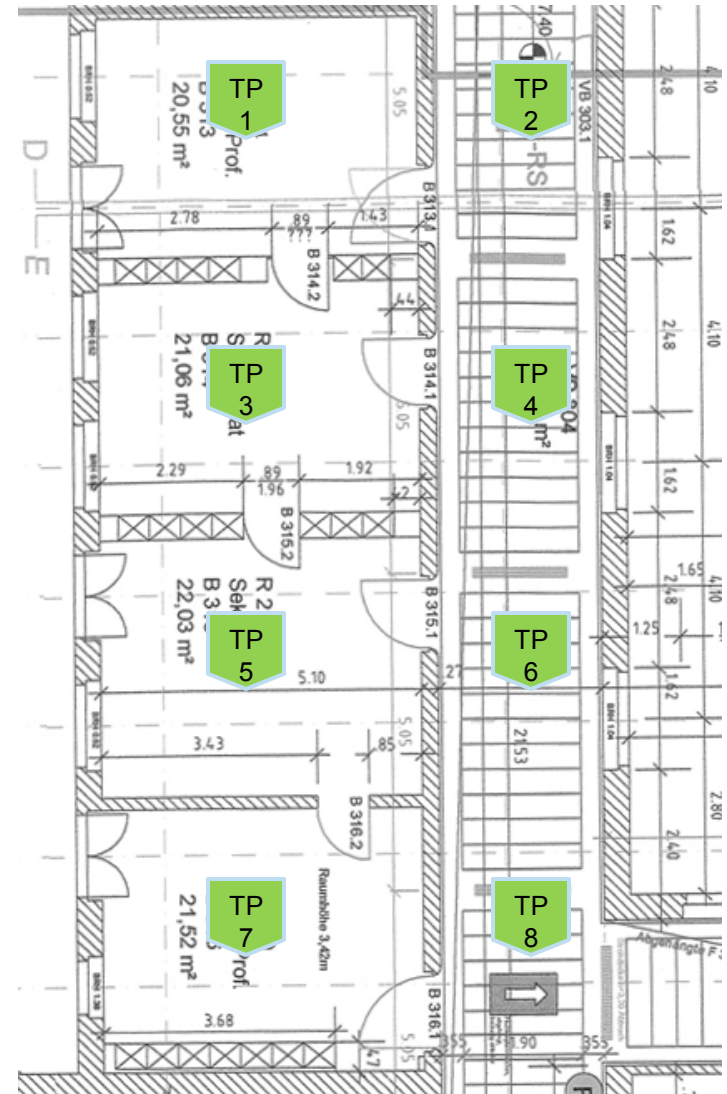
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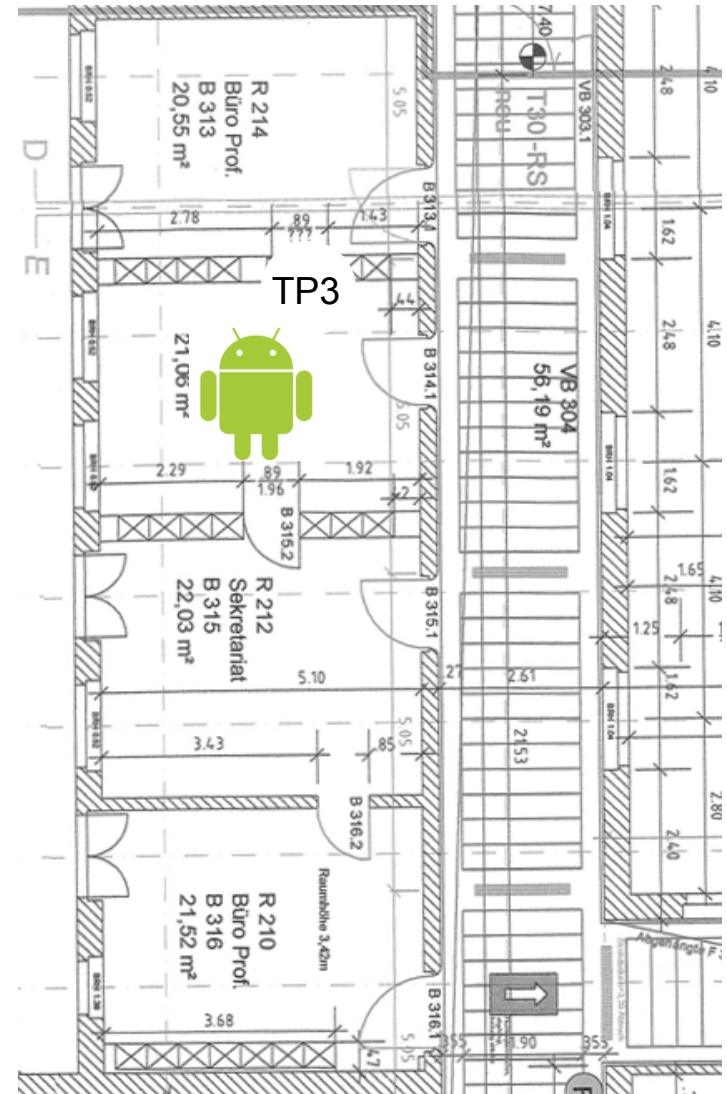
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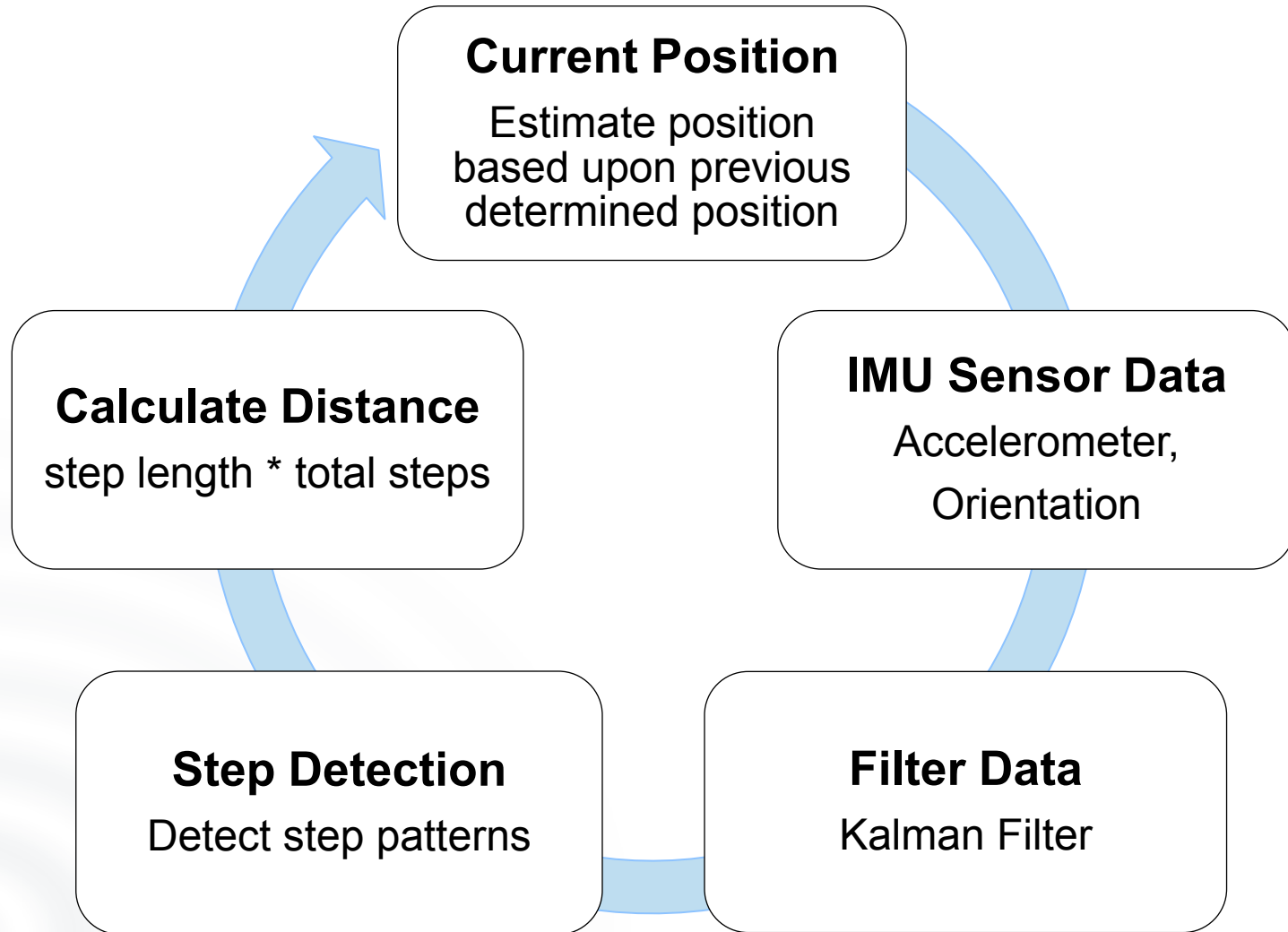
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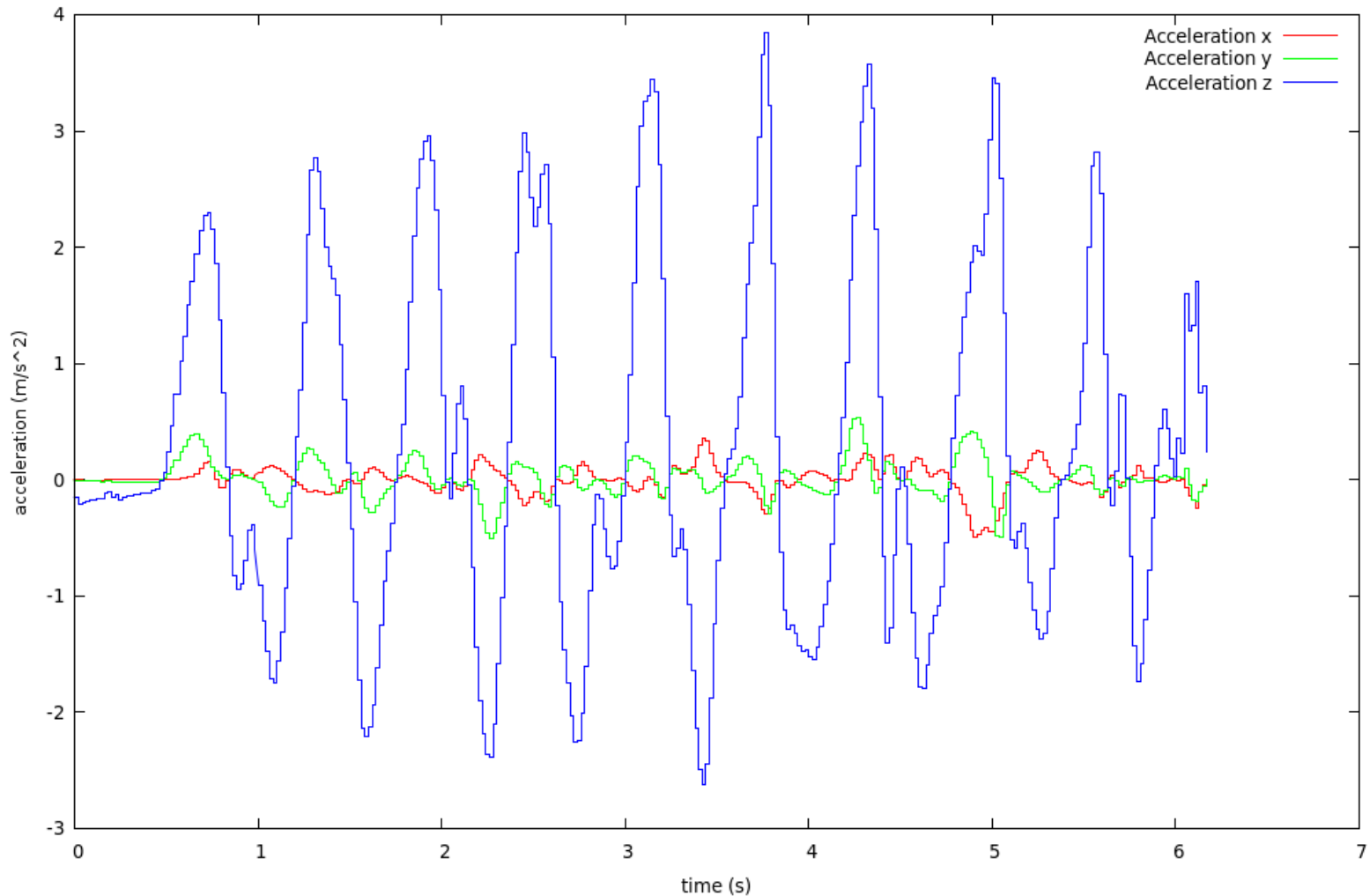
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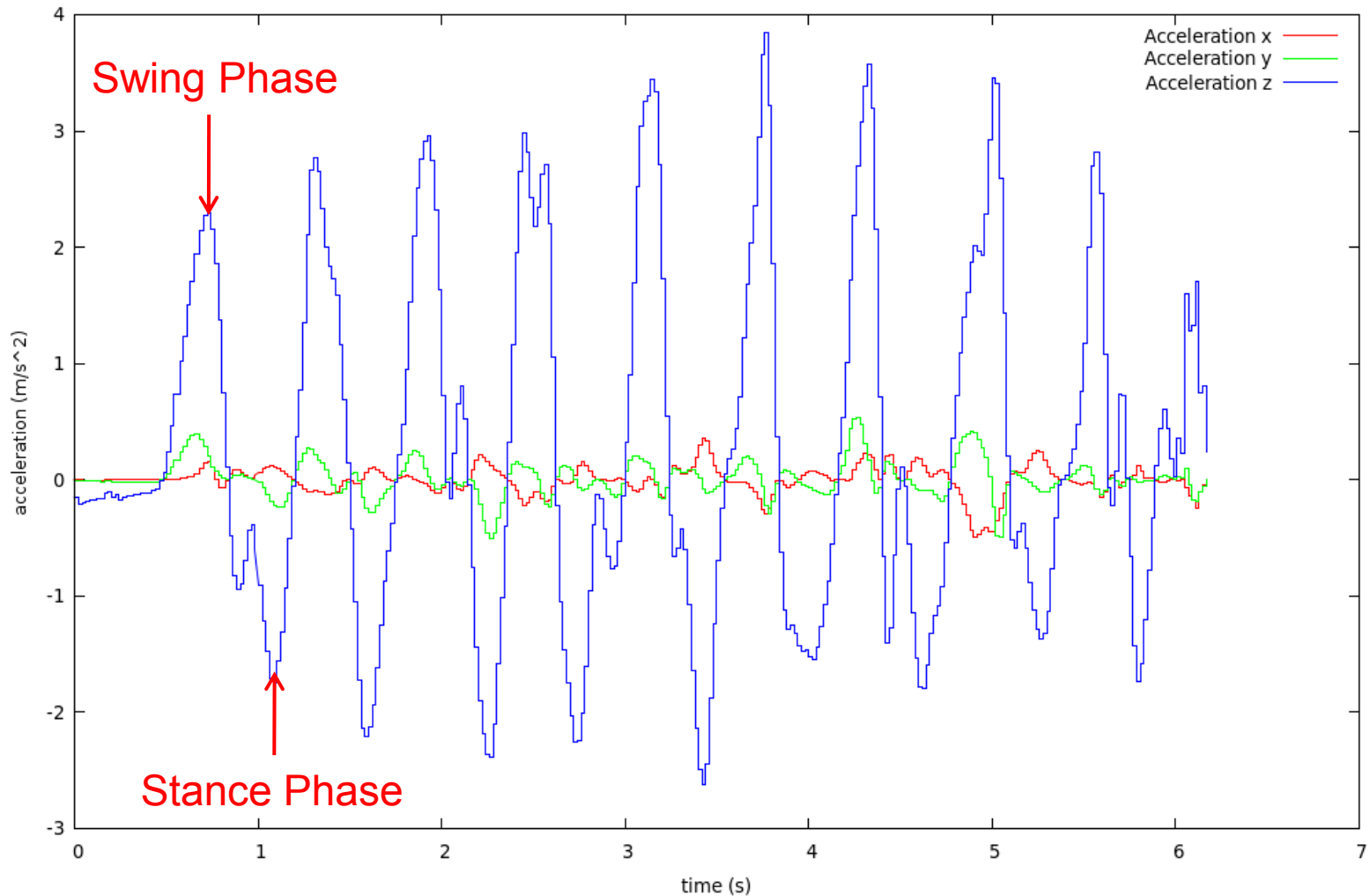
# IMU Localisation – Dead Reckoning



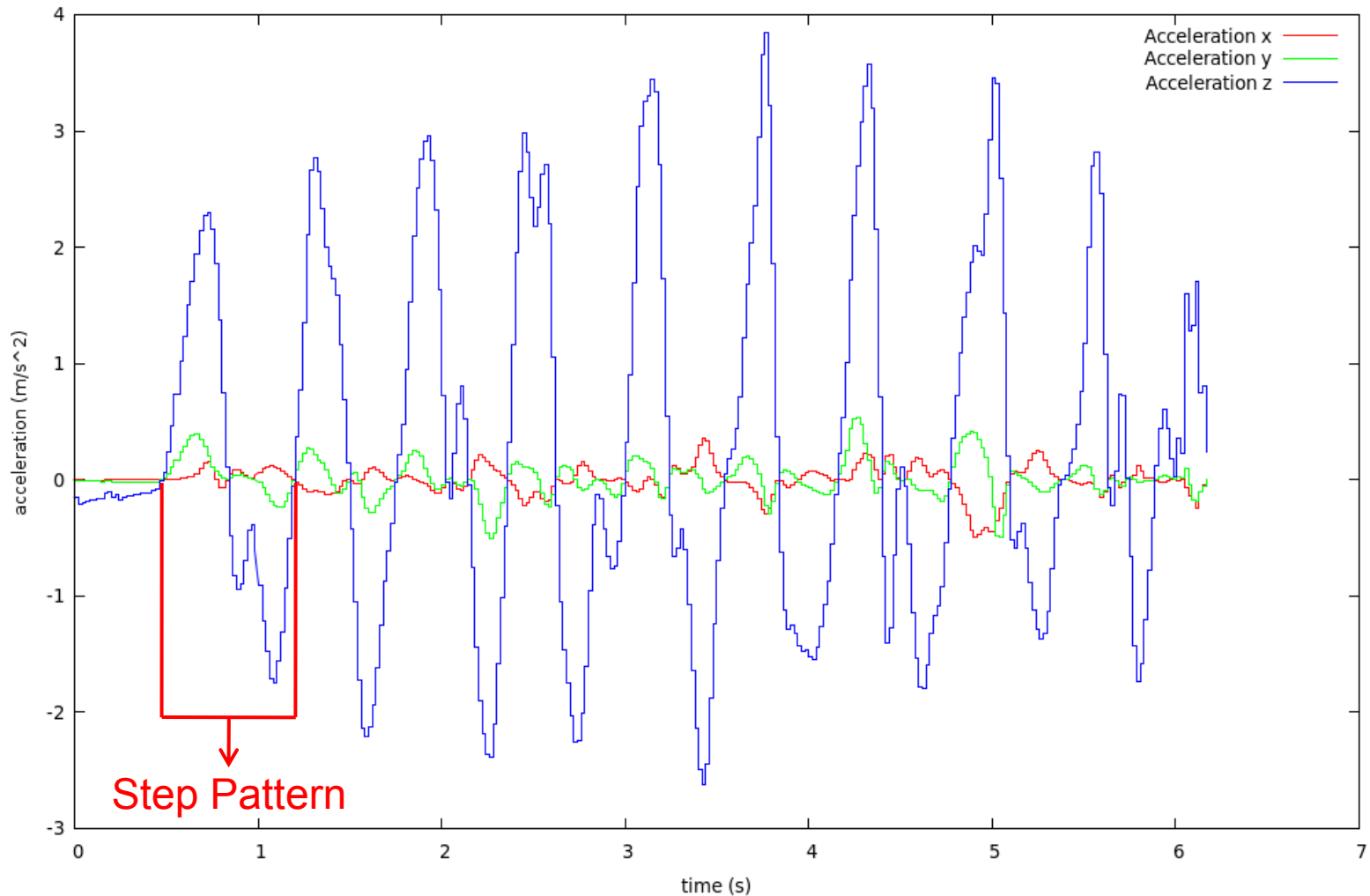
# IMU Localisation – Step Detection



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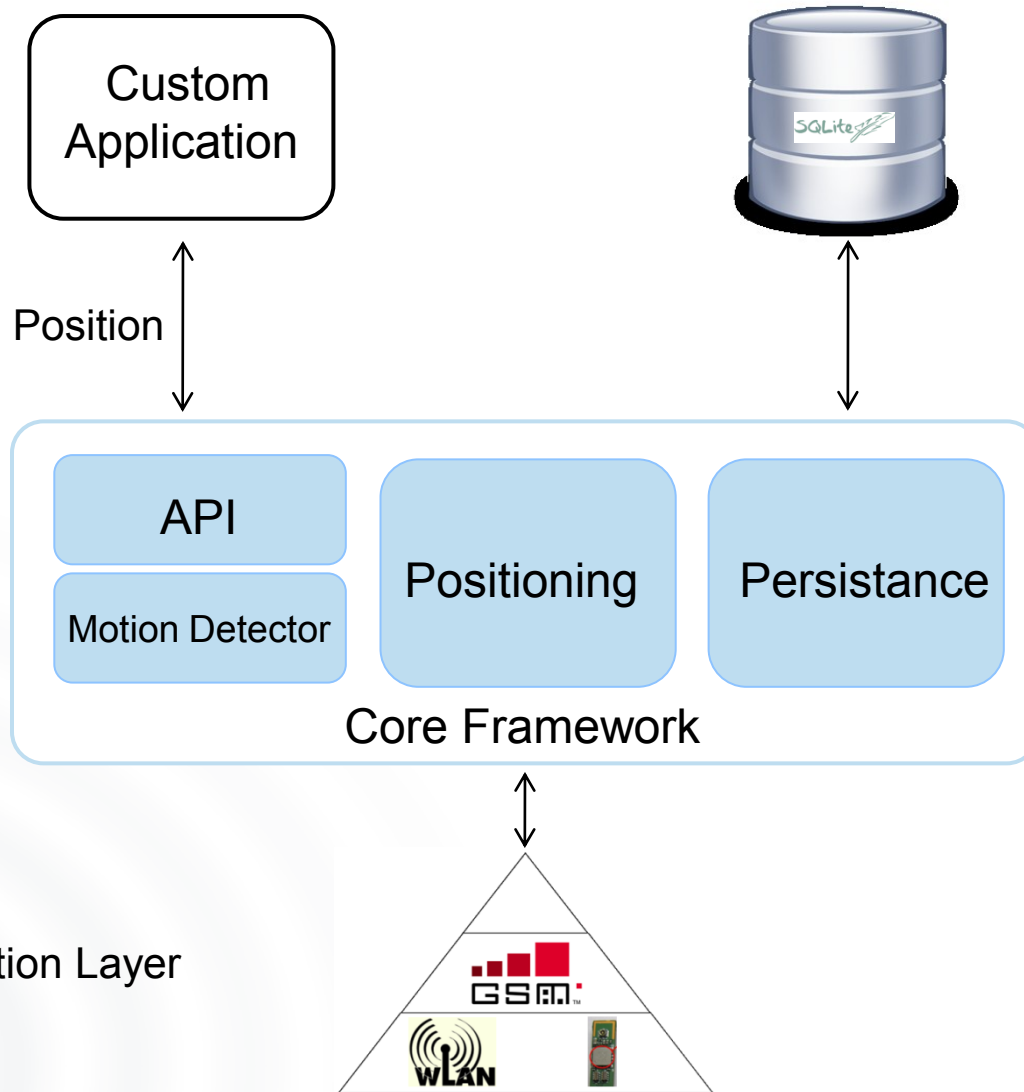




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# SSF - Architecture

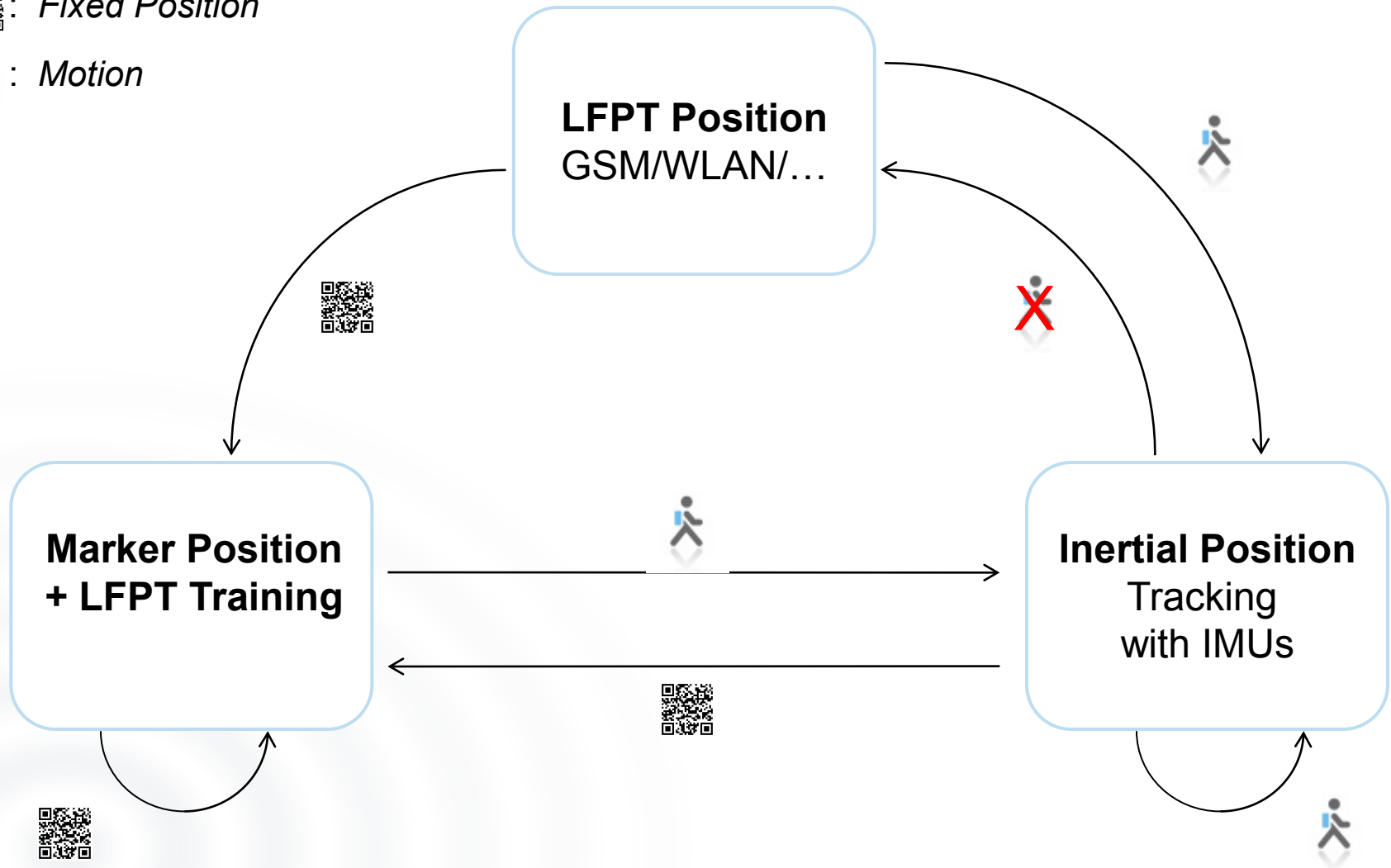


Sensor Synchronization Layer

# SSF- Core Framework

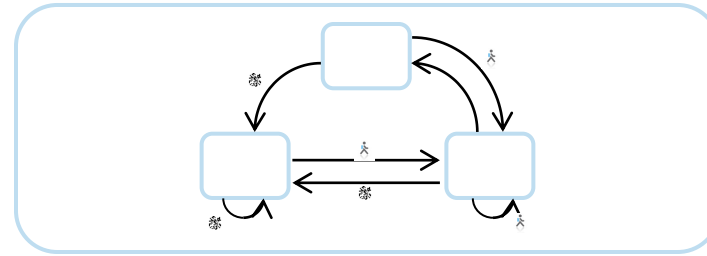
 : Fixed Position

 : Motion



# SSF - Sensor Synchronization Layer

Core Framework

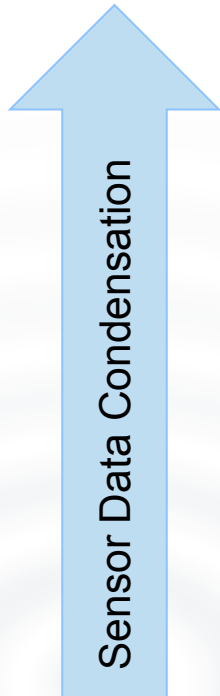


Synchronization Strategy

Sensor Fusion

Sensor Data Processing

Raw Sensor Data



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# New kinds of applications can be built

- **Context aware Applications**
  - Localization of resources
  - Automated service execution
  - Implicit context recording, for later retrieval
- **Household Applications**
  - Room profiles
  - Light applications
  - Energy saving
- **Shopping center**
  - Augmented (Reality) product search
- ...

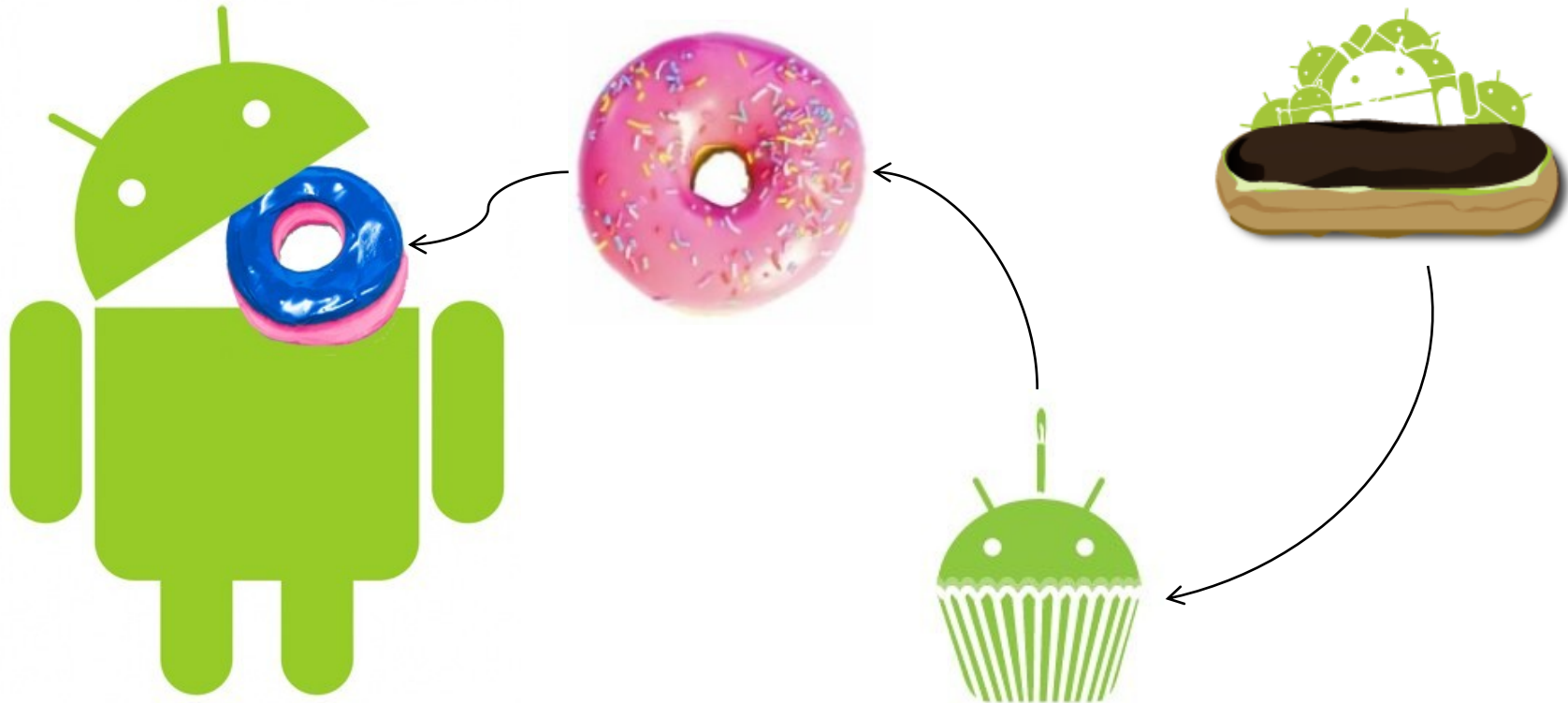
# SmartSpace Platform: Summary

- Extends the android platform by indoor localisation capabilities
- Uses WLAN, GSM/CDMA, IMUs and Camera
- Uses existing RF-infrastructure
- Sensor Fusion
- On-site positioning
- Autonomous Learning
- Trainings .apk
- Open Source

Everybody can use it!

# Thank you!

Take everything you can get and cope with it!





# Questions??

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# Future of Localisation

